The validity of retrospective session-rating of perceived exertion to quantify training load in youth athletes.

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ABSTRACT

Youth athletes frequently participate in multiple sports or for multiple teams within the same sport. To optimise player development and minimise undesirable training outcomes (e.g., overuse injuries), practitioners must be cognizant of an athlete's training load within and outside of their practice. The present study aimed to establish the validity of a 24-hour (s-RPE$_{24}$) and 72-hour (s-RPE$_{72}$) recall of session rating of perceived exertion (s-RPE) against the criterion measure of s-RPE collected 30 minutes' post training (s-RPE$_{30}$). Thirty-eight adolescent athletes provided a s-RPE$_{30}$ following the first field based training session of the week. Approximately 24 hours later subjects were asked to recall the intensity and duration of the previous days training. The following week subjects once again provided a s-RPE_{30} measure post training before recalling the intensity and duration of the session approximately 72 hours later. A *nearly perfect* correlation (0.98 [0.97 – 0.99]) was found between s-RPE_{30} and s-RPE_{24}, with a *small* typical error of estimate (TEE; 8.3% [6.9 – 10.5]) and *trivial* mean bias (-1.1% [-2.8 – 0.6]). Despite a *large* correlation between s-RPE_{30} and s-RPE_{72} (0.73 [0.59 – 0.82]) and a *trivial* mean bias (-0.2% [-6.8 – 6.8]) there was a *large* typical error of estimate (TEE; 35.3% [29.6 – 43.9]). s-RPE_{24} provides a valid measure of retrospectively quantifying s-RPE, however the large error associated with s-RPE_{72} suggests it is not a suitable method for monitoring training load in youth athletes.

Keywords: adolescent, soccer, rugby, hockey

INTRODUCTION

Training load comprises of the stress placed on an athlete from a single or multiple sessions over a training block (16). The quantification of load can be considered from both an external and internal load perspective. External load is represented by the work performed by the athlete (e.g. actions, distance covered, high speed running) (9) whilst internal load identifies the physiological stress experienced by the athlete in response to the external load (e.g. heart rate) (9). The monitoring and manipulation of training intensity, frequency and duration is important to optimise athletic development, whilst also minimising the risk of non-functional overreaching and overuse injury (15).

Youth athletes are at risk of maladaptive training exposures as they frequently participate in multiple sports (2) or in multiple teams or age categories within the same sport (Phibbs et al., 2016), often under numerous coaches. Subsequently, each coach must be cognizant of the entire training load encountered by the athlete to allow sufficient recovery between training sessions and to minimise the risk of overuse injuries (4). Additionally, previous research has discovered 20% of children who play at school or regional level experience non-functional overreaching at some point in their careers (15). A potential mechanism for the development of non-functional overreaching is the additional stress placed on the youth athlete through external sources such as schoolwork, relationship stresses and pressure from parents/coaches alongside the fatigue derived from sports training (15). Therefore, non-functional overreaching should be as much of a consideration for the schoolteacher or local club coach as for those coaches involved with higher level youth athletes. The adverse outcomes associated with overuse injuries and non-functional overreaching include sporting burnout (4) and the athletes' withdrawal from sport. Withdrawal from sport, sacrifices the potential benefits of sporting participation including improvements in physical fitness, reduced metabolic disease risk and developments of self-esteem (5). Such negative consequences further highlight the importance of training load monitoring and the minimisation of undesirable training responses.

One such method of monitoring an individual's training load is through the session rating of perceived exertion (s-RPE). Although the reliability of s-RPE has yet to be established due to the difficulty in determining the reliability of ordinal scales (19), s-RPE has been shown to be a valid method of quantifying internal training load in intermittent team sports (3,13,14), offering a cost-effective and simple alternative to heart rate based methods. Following a training session, individuals are required to provide a measure of intensity based on how hard they thought the session was which is then multiplied by the perceived duration of the session to establish a measure of training load in arbitrary units. Previous research (7,20) has suggested the ideal time for RPE collection is between 10 and 30 minutes following the cessation of exercise to prevent bias towards activities completed at the end of the training session.

Although guidelines as to the most appropriate time to acquire an RPE have been established, the time at which s-RPE ceases to accurately represent the session load remains unclear. Weekly recall diaries are often used within practice but are suggested to have limitations in terms of accuracy (1). Recent research (18) within adolescent rugby players advocated the use of s-RPE up to 24 hours' post training however suggested that a 7-day recall diary may not be suitable due to the substantial typical error associated with the longer time lapse. Despite this, the suitability of s-RPE appears to sustain beyond 24 hours, with research (6) in youth football finding 48-hour s-RPE recall to be an appropriate measure of training load quantification.

As previously mentioned, the participation in multiple sports or at multiple levels within the same sport makes it extremely difficult for coaches and schoolteachers to monitor an athletes training load 10-30 minutes' post training for every session. Existing literature is ambiguous as to the time frame in which retrospective s-RPE ceases to accurately represent the training load experienced by an athlete. Consequently, there is a clear need to identify a window of recall whereby the individual can accurately identify the intensity and duration of training exposures coaches or practitioners were not present at. Such findings would facilitate the monitoring of internal training load and optimise the manipulation of an individual's training dose. On the other hand, failure to correctly account for an individual's training load will leave that individual susceptible to a maladaptive training response predisposing the athlete to overtraining, injury and potential sporting burnout. Therefore, the aim of the present study was to provide practitioners with a greater clarity regarding the timeframe in which the validity of retrospective s-RPE begins to diminish by assessing 24 (s-RPE_{24}) and 72 (s-RPE_{72}) hour recall against the criterion measure of s-RPE taken 30 minutes following training (s-RPE_{30}).

METHODS

EXPERIMENTAL APPROACH TO THE PROBLEM

The present study sought to determine the validity of 24-hour and 72-hour recall of s-RPE (and its constructs, intensity and duration) by assessing their level of agreement to the criterion measure of s-RPE given 30 minutes' post training. The study was completed in the month of April over a two week in-season period with coaches instructed to carry out their training session as normal and in keeping with their periodised training plan. The lead researcher offered no instruction to coaches as to how training sessions should be structured. The criterion measure of s-RPE_{30} was obtained 30 minutes following the first school training session of week one. The validity of s-RPE_{24} was investigated by asking subjects to recall the intensity and duration of the first school training session of week one approximately 24 hours after providing s-RPE_{30}. At the start of week two, the criterion measure of s-RPE_{30} was once again obtained following the first school training session of the week. The validity of s-RPE_{72} was assessed by asking subjects to recall the intensity and duration of the first school training session of week two approximately 72 hours after providing s-RPE_{30}. Both s-RPE_{24} and s-RPE_{72} were compared against the previously validated (3,13,14) criterion measure of s-

RPE_{30} to establish the accuracy of both recall timeframes. All subjects were familiar with the s-RPE_{30} method as it was a frequently used method of training load quantification prior to the commencement of the study. All subjects were advised to keep their dietary and sleeping patterns consistent throughout the experimental period.

SUBJECTS

Thirty-eight adolescent athletes (mean ± standard deviation (SD); age 17.8 ± 0.6 years; height 173.6 ± 9.7 cm; body mass 74.6 ± 14.4 kg) representing three different sports (hockey, rugby and football) were recruited from an independent school in the United Kingdom. All athletes had at least 3 years' experience of playing their sport (8.6 ± 3.6 years). Ethics approval was granted by the University Human Research Ethics Committee and all participants and parents were provided with a plain language statement outlining the procedures and potential benefits and risks of participation. Following an opportunity to ask any questions regarding the study to the lead researcher, all participants and parents provided written informed consent prior to participation.

PROCEDURES

S-RPE_{30}

Following the first school training session of both week one and week two, subjects provided a RPE measure as well as a session duration to the nearest minute to the lead researcher. The RPE selection was made non-verbally, by pointing to the desired text descriptor on a modified Borg category ratio-10 (CR-10) scale, in isolation from other subjects to avoid external influence on selection. Measures of RPE were taken 30 minutes following each training session to avoid any influence the activities completed towards the end of each training session may have had on RPE. The time at which each subject provided their session duration and intensity was recorded to ensure recall times were kept as close to 24 and 72 hours as possible. The RPE anchor was then multiplied by the previously ascertained session duration to calculate a load measure in arbitrary units.

S-RPE$_{24}$

To establish s-RPE$_{24}$, subjects were asked to provide a session duration and intensity measure for the first school training session of week one approximately 24 hours later (matched against the time their s-RPE$_{30}$ was provided) using the same CR-10 scale to the lead researcher. Session durations and intensities were collected in isolation to prevent subjects conferring with regards to the previous day's session. The intensity measure was once again multiplied by the session duration to provide a load measure in arbitrary units.

S-RPE$_{72}$

On the subsequent training week, another s-RPE$_{30}$ measure was attained after the first school training session of the week, using the same protocol as the previous week. Approximately 72 hours later subjects provided the lead researcher with a session duration and intensity measure for the first school training session of week two in isolation, again using the same CR-10 scale. The recalled intensity and duration were multiplied together to give a load measure in arbitrary units.

STATISTICAL ANALYSES

Agreement between the criterion s-RPE$_{30}$, s-RPE$_{24}$ and s-RPE$_{72}$ as well measures of intensity and duration at each time point were assessed using an excel spreadsheet designed to calculate the mean bias ($\bar{!}$"#$$/$\bar{!}$%&#'(&#)*)x100), typical error of the estimate (TEE; $+,_{diff}/\sqrt{2}$) and Pearson correlation coefficient (10). Confidence intervals were set at 90%. All data were log-transformed for analyses to reduce bias as a result of non-uniformity error (100 x log(*raw value*)), excluding the regression analysis (10). Raw data were presented to report the regression equations, mean and SD of the criterion and practical measures. Standardised measures were calculated using back-transformed data based on the Cohen's *d* effect size principle using the following equation; ($\bar{!}_{practical}$ - $\bar{!}_{criterion}$)/$SD_{criterion}$) (10). Standardised mean bias was rated as *trivial* (<0.2), *small* (0.2-0.59), *medium* (0.6-1.19) or *large* (1.2-1.99) (11). Standardised TEE was rated as *trivial* (<0.1), *small* (0.1-0.29) *moderate* (0.3-0.49), *large* (0.5-0.69) *very large* (0.7-0.89) or *nearly perfect* (0.9-0.99) (10). The magnitude of the correlations was assessed using the following boundaries; r= 0.1-0.29 is *small*, 0.3-0.49 = *moderate*, 0.5-0.69 = *large*, 0.7-0.89 = *very large*, 0.9-0.99 = *nearly perfect*, 1 = *perfect* (11).

RESULTS

Table 1 displays the agreement between s-RPE_{30} and s-RPE_{24} for s-RPE, perceived duration and intensity. Table 2 displays the agreement between s-RPE_{30} and s-RPE_{72} for s-RPE, perceived duration and intensity. The regression plots for the agreement between the criterion s-RPE_{30} and practical measure s-RPE_{24} for s-RPE, intensity and perceived duration are presented in figure 1, whilst figure 2 displays the regression plots for the agreement between s-RPE_{30} and s-RPE_{72}.

Nearly perfect correlations were found between s-RPE$_{30}$ and s-RPE$_{24}$ for s-RPE, intensity and duration. The standardised TEE was *small* between s-RPE$_{30}$ and s-RPE$_{24}$ for s-RPE, intensity and duration whilst standardised biases were *trivial* for s-RPE, intensity and duration.

Although *very large* correlations were found between s-RPE$_{30}$ and s-RPE$_{72}$ for s-RPE, intensity and duration, the standardised TEE was *large* for s-RPE, *moderate* for intensity and *very large* for duration. The standardised mean bias was *trivial* for s-RPE and intensity but *small* for duration.

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DISCUSSION

To optimise training periodisation practitioners must be cognizant of an athletes' training load within and outside of their practice. As it is not always possible for the coach to obtain a s-RPE 30 minutes' post training, a reliable window of recall must be established. Such findings would provide practitioners with a timeframe in which they can confidently assume the s-RPE provided by the athlete accurately reflects the load imposed from the training session. Therefore, the purpose of the current study was to assess the validity of s-RPE_{24} and s-RPE_{72} against the criterion measure of s-RPE_{30}. The study found that s-RPE_{24} showed high levels of agreement with s-RPE_{30} however there was a large amount of error when subjects were asked to recall training from 72 hours prior.

In line with previous research in youth athletes (18), s-RPE_{24} and its constructs of intensity and time had a nearly perfect correlation with s-RPE_{30}, a trivial mean bias and a small TEE. Subsequently, s-RPE_{24} can be considered a valid method of monitoring internal training load providing coaches and practitioners with a simple, quick and cost-efficient method of retrospectively quantifying load.

On the other hand, despite a very large correlation with s-RPE_{30}, the large TEE associated with session-RPE_{72} restricts its application to practice. Recent research (12) has identified week to week spikes in training load to be associated with injury and illness. A >15% increase on the previous weeks training can escalate injury risk to between 21% and 49% with an increase of <10% recommended to minimise injury risk (8). The present study found the error associated with s-RPE_{72} to be 35.5% meaning s-RPE_{72} would not be sensitive enough to detect small and potentially crucial changes in training load, leaving the individual susceptible to injury. A potential explanation for the error associated with s-RPE_{72} is that the sessions subjects were attempting to recall were perceived, on average, to be moderate. Had the sessions been of a higher intensity, the stress placed on the individual may have led to a stronger anchoring of intensity as suggested to occur during match play (6).

Previous literature (6) has demonstrated the validity of 48 hour RPE recall in youth footballers, whilst weekly training diaries have been found to contain too much error to be used confidently (18). Therefore, findings of the present study enhance current knowledge by establishing the timeline whereby the validity of s-RPE recall appears to diminish. Subsequently, coaches and practitioners must establish a method of quantifying an individual's training load within 72 hours of the training activity occurring to be confident the load measure obtained accurately reflects the load experienced by the individual.

LIMITATIONS

Subjects were individually reminded that it was not a memory test and that the RPE and duration given should represent their perceptions at that time rather than their response given 30 minutes' post training. Prior research (6) has demonstrated that the ability to remember a previously given RPE does not influence response shift when recalling RPE. However, this does not entirely eradicate the possibility of subjects remembering and reporting values given at s-RPE_{30} when asked to recall at s-RPE_{24} and s-RPE_{72}. Additionally, all s-RPE measures in the present study were taken following training sessions. Recall accuracy has been found to improve following match play in comparison to training (6), therefore the validity of s-RPE_{24} and s-RPE_{72} may need to be examined following a competitive fixture to further understand recall precision.

PRACTICAL APPLICATIONS

Training load manipulation is required to elicit improvements in performance whilst minimising the risk of non-functional overreaching and overuse injury (4). To attain a holistic quantification of an individual's training load, coaches & practitioners require an accurate method of collecting retrospective perceptions of intensity and duration from sessions they were not present at. The present study found S-RPE_{24} to offer a valid measure of internal training load quantification. Despite this, the precision of recall does not extend to 72 hours with the large error associated at s-RPE_{72} meaning small and meaningful changes in training load would be missed, predisposing to errors in training load management. Therefore, coaches and practitioners should seek to implement a method of monitoring training load which establishes the athletes s-RPE within 72 hours of the training activity taking place.

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Table 1. The level of agreement between s-RPE$_{30}$ and s-RPE$_{24}$ for s-RPE, intensity and duration. Data are mean ± standard deviation, log-transformed mean bias (Mean bias %), standardised mean bias (Standardised bias), percentage typical error of the estimate (TEE%), standardised typical error of estimate (Standardised TEE) and Pearson correlation coefficient (Correlation), all with 90% confidence limits.

Measure	**S-RPE$_{30}$**	**S-RPE$_{24}$**	**Mean Bias % (Standardised Bias)**	**TEE % (Standardised TEE)**	**Correlation**
S-RPE (AU)	134 ± 62	134 ± 66	-1[-2.8 - 0.6] (-0.02 [-0.06 – 0.01])	8.3[6.9 – 10.5] (0.18 [0.15 – 0.22])	0.98 [0.97 – 0.99]
Intensity (AU)	2.6 ± 1	2.6 ± 1	-0.7[-2.2 - 0.8] (-0.02 [-0.06 – 0.02])	7.1[5.9 – 8.9] (0.18 [0.15 – 0.22])	0.98 [0.97 – 0.99]
Duration (min)	52 ± 14	51.8 ± 14	0.2[-5.7 – 6.5] (-0.01 [-0.04 – 0.02])	4.4[3.7 – 5.5] (0.13 [0.11 – 0.16])	0.99 [0.99 – 1]

Table 2. The level of agreement between s-RPE$_{30}$ and s-RPE$_{72}$ for s-RPE, intensity and duration. Data are mean ± standard deviation, log-transformed mean bias (Mean bias %), standardised mean bias (Standardised bias), percentage typical error of the estimate (TEE%), standardised typical error of estimate (Standardised TEE) and Pearson correlation coefficient (Correlation), all with 90% confidence limits.

Measure	**S-RPE$_{30}$**	**S-RPE$_{72}$**	**Mean Bias %** **(Standardised Bias)**	**TEE %** **(Standardised TEE)**	**Correlation**
S-RPE (AU)	148 ± 62	145 ± 55	-0.2[-6.8 – 6.8] (-0.01 [-0.16 – 0.15])	35.3[29.6 – 43.9] (0.69 [0.59 – 0.83])	0.73 [0.59 – 0.82]
Intensity (AU)	3 ± 1	2.7 ± 1			0.83 [0.75 – 0.89]
			-5.8[-10.7 - -1.0] (-0.15 [-0.27 – 0.02])	26.6[22.4 – 32.8] (0.56 [0.48 – 0.67])	
Duration (min)	50.6 ± 12	54 ± 11	6.3[2.3 – 10.1] (0.27 [0.10 – 0.43])	17.1[14.5 – 21] (0.71 [0.61 – 0.85])	0.71 [0.57 – 0.81]

Figure 1. Regression plots for agreement between criterion (s-RPE$_{30}$) and practical measure (s-RPE$_{24}$) for A) s-RPE B) Intensity C) Time

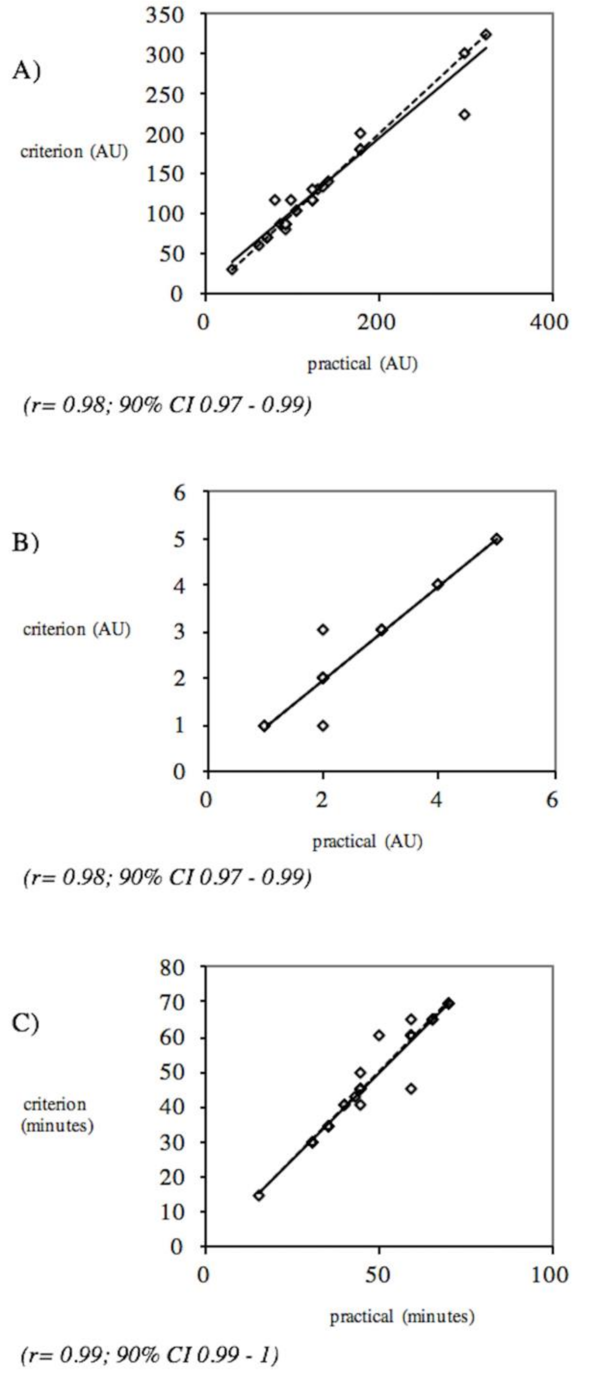
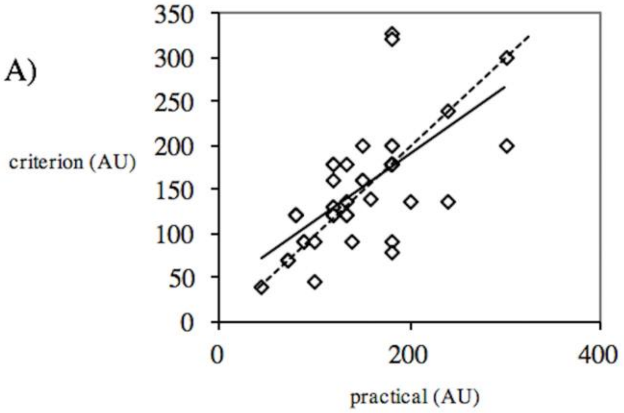
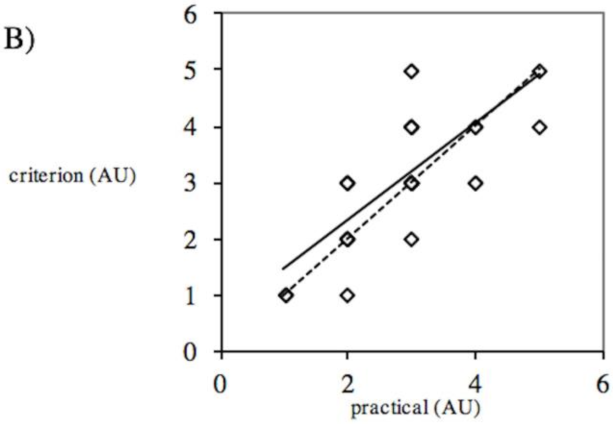


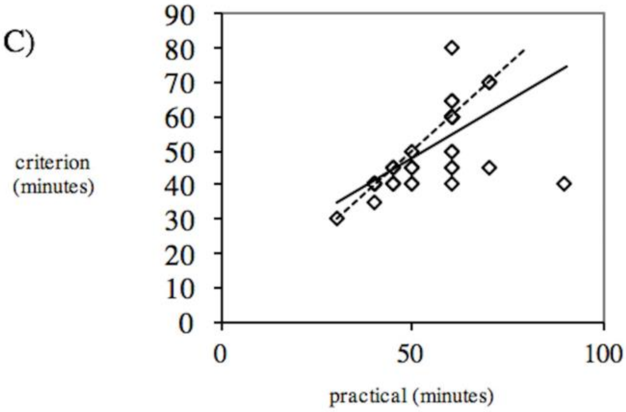
Figure 2. Regression plots for agreement between criterion (s-RPE$_{30}$) and practical measure (s-RPE$_{72}$) for A) s-RPE B) Intensity C) Time



(r=0.73; 90% CI 0.59 - 0.82)



(r=0.83; 90% CI 0.75 - 0.89)



(r=0.71; 90% CI 0.57 - 0.81)

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